ENGINEERING CASE LIBRARY

ECL 235

ENGINEER; MY FIRST EXPERIENCE

Co-op student Michael Helmey was asked to investigate the merits of replacing a steam ejector on an ash conveying system with a motor driven vacuum pump. He finds that besides his knowledge of fundamentals, he can use good advice from a vendor and from another plant with ash handling problems.

ENGINEER; MY FIRST EXPERIENCE

Where do I begin?

That was my immediate thought when asked to investigate the cost, feasibility, and return of replacing a steam ejector on an ash[1] conveying system with a motor driven vacuum pump.

When the request was made, I was employed as a co-op student from the University of South Florida with Union Camp Corporation in Savannah, Georgia. Their plant in Savannah, being the largest pulp and paper mill in the world, handles all phases of the papermaking process, from harvesting the tree to making paper containers. Also, the mill makes and uses its own energy from six separate power boilers.

In mill engineering where I was working, sixteen engineers and thirteen draftsmen (including myself) had the job of constantly repairing and updating existing mill operations. The ash handling project given to me was no different from these routine assignments except that this time, to my surprise, _I_ was to be the engineer!

My supervisor (and project engineer), Jerry Brown, had decided that, as a help to my education, I be given a project in which I would handle all the necessary engineering. The project he chose for me turned out to be very challenging and interesting, (although sometimes frustating!)

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[1] "Ash" refers to the solid residue left at the bottom of a power boiler as a result of burning fuel. Its size varies from fine particles, called fly ash, to chunks up to 4 inches in diameter, called bottom ash.

Jerry's letter assigning me the project is in the appendix, page 12. Also, on page 11 is the original request for engineering for the project, originated by Jim Riggs, the superintendent of the power department.

As stated in Jerry's letter, my task was to determine if a standard motor driven vacuum pump could be used to "pump" ash from the bottom of two power boilers to a common storage silo. The existing method of conveying the ash used 165 psig steam ejected through a venturi tube to create the required vacuum. Because of the high cost of steam, a more economical method was desired.

Well, now that I knew what I was supposed to do, where was I to begin? I knew next to nothing about the ash handling system, having only vague ideas about how it operated. My first task, therefore, was to familiarize myself with the existing system.

Consulting our office files, I found the original drawings of the system. Carrying the blueprints to the mill, I finally began to understand how it operated.

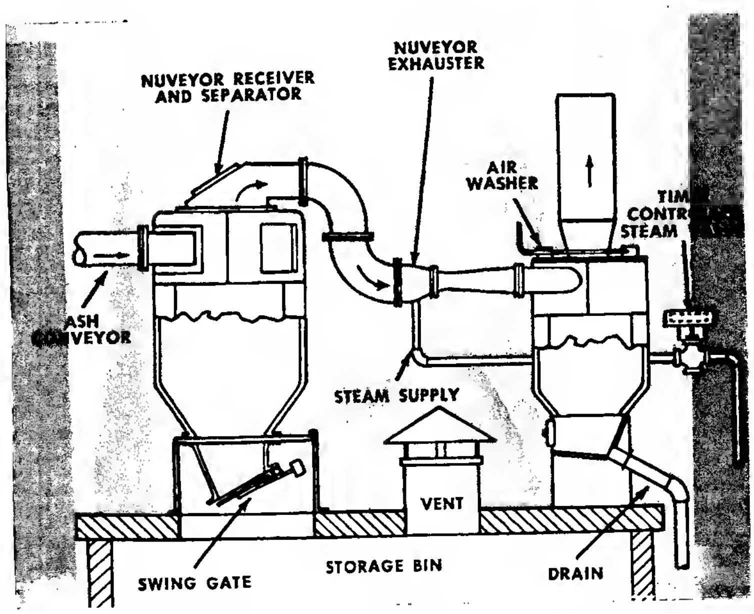
Essentially the ash handling system is designed to transport the ash created from burning wood and oil in our no. 11 and no. 12 power boilers to a storage silo. Twice each night a truck parks under the silo, collects the ash, then hauls it off to a land fill area. On page 13 of the appendix are data on the power boilers and ash. Figure 1 shows the ash silo and truck unloading area.

Truck loading area at the base of the ash silo.

Ash storage silo.

Figure 1

To start the system working, the boiler operator pushes a remote control switch located on the boiler control panel. This starts a small timer motor which actuates a solenoid valve in the steam supply line, supplying 165 psig steam to a multi-jet exhauster (venturi tube). This multi-jet exhauster then creates 15" Hg vacuum, drawing a large volume of air out of the receiver-separator (refer to figure 2). This causes an inrush of air past the swinging discharge gate, closing it tight, preventing ash from being drawn back out of the silo. A high velocity flow of air through the conveyor pipe is then created.



Existing ash handling equipment located on top of the storage silo.

Figure 2

This air carries the dry ash from the hoppers at the bottom of the boilers to the receiver-separator on top of the storage silo. On page 14 is a photo of the receiver separator. The ash and air enter the receiver tangentially, creating a cyclone effect, which together with baffles, separates the ash from the air. The ash collects at

the bottom of the separator while the air is drawn out through the top, finally passing through the steam exhauster.

The steam remains on for 75 seconds, whereupon the steam valve is automatically closed by the timer for 15 seconds. This breaks the vacuum, allowing the separator gate to swing open and drop the ash into the storage silo. The air and the steam from the exhauster are discharged to an air washer which washes the air before it is finally discharged to the atmosphere.

The cycle is repeated automatically until all the ash is removed from one boiler, when the operator again pushes a remote control switch which transfers the operation to the other boiler.

One observation I made while viewing the system was that the area around the silo was extremely dirty due to ash covering everything. So much ash accumulates under the silo daily that it's necessary for a man to shovel a path for the truck to get through!

Having watched the system working, I decided to talk with the people who operated it to discuss any current problems they were having. To my surprise, there were quite a few existing problems.

According to Ed Thompson, the assistant superintendent of the power department, the main trouble areas were recurring vacuum leaks in conveying lines, steam jets wearing out and occasional clogged up piping. Also, David Horn, the no. 11 boiler operator, told me that sometimes not enough vacuum was developed to convey the ash. I later found out from our accounting department that an average of $35,000 per year was being spent on maintenance of the ash handling system.

Now that I understood just how the system worked and what its problems were, I could determine if installing a vacuum pump would be both feasible and economical. I decided to determine some of the economics of it first.

On page 15 in the appendix are calculations showing the cost per year for supplying steam to the steam exhauster versus the cost per year of running a motor driven pump. The cost of steam was calculated to be $36,000 per year whereas the cost to run a motor was $23,700 per year, therefore saving $12,300 per year.

So far so good. All it seemed I had to do now was size a pump, determine the best arrangement to install it and estimate installation cost. If all went well I would have the project finished smoothly in no time at all. Well, all didn't go so well.

While talking with suppliers of ash handling equipment, I learned that vacuum pumps generally were not used in this type of operation. The main reason was that the ash could not be filtered out of the air efficiently enough to keep the pump blades from wearing out. Two alternate methods were suggested; one was to replace the steam ejector with an air blower, the other to transport the ash wet in a sluicing system.

I thought to myself that using an air blower would not be such a bad idea. The installation and operating cost would probably be about the same as those of a vacuum pump. Transporting the ash wet, however, was out of the question due to the enormous installation costs. After thinking on these suggestions for awhile, I decided

to contact some of Union Camp's other mills to see what methods they were using to convey ash.

When I phoned our paper mill in Franklin, Virginia, I got quite a shock. Harold Miller, the assistant superintendent of the power department there, told me that just one month earlier their ash storage silo had exploded! Inquiring further, I learned that their ash handling system was similar to ours, and that they had some of the same problems we did.

Asking about the explosion, he told me that it had happened when a workman opened a manhole at the top of the silo during inspection. A quick inrush of oxygen mixed with fine fly ash in the silo, causing spontaneous ignition. This resulted in severe damage to the silo.

Mr. Miller commented further that the explosion occurred soon after installing precipitators on their boilers, thereby introducing the super fine fly ash into the system. He also said that, immediately prior to the explosion, they had been plagued by several small fires, also a result of the precipitators. His last comment was that they were considering changing over to a wet ash handling system.

Well, it seemed as if my project had taken an entirely new direction. I knew that our construction engineering group was in the design stages of installing scrubbers on our boilers, which meant that we would be placing ourseleves in the same situation as the mill in Franklin.

Not knowing exactly what to do next, I went to Jerry and explained the situation. Realizing the safety problems now involved, we decided to investigate both wet and dry ash conveying systems, dropping the vacuum pump idea.

To get more information on the use of air blowers and dry ash handling, I called Fuller Company in Atlanta who specializes in moving bulk materials. Several days later, Bob Fox, their sales engineer, came to my office and together we discussed the best arrangement for using an air blower.

In order to size the blower, we assumed the bulk density of the ash would be 25 lbs. per cubic foot and its temperature about 300 degrees Fahrenheit. Also, according to data gathered by our mill technical department, the blower needed a capacity of 2280 cfm at 8" Hg. (See page 15 for flow data). We chose a blower with a rated capacity of 2660 cfm at 12" Hg requiring a 100 HP motor. A more effective receiver-separator was also chosen to replace the existing one. The total estimated cost for this equipment was quoted at $54,000.

I next contacted Tom Lyndon with United Conveyor Corporation out of Chicago to discuss transporting the ash wet. Viewing our mill's operation together, we came up with the best method for converting over to a wet ash handling system. This involved installing a mechanical blower, a water receiver-separator to replace the existing dry separator, and a new dewatering bin to replace the dry storage silo. The existing system would remain intact up to the receiving equipment on the top of the existing silo. The present dry receiving equipment would be replaced with the water receiver, which separates the ash out by centrifugal action and a water spray. The ash slurry mixture would drain to the dewatering bin located immediately west of the silo. It is used to alternately collect and dewater the slurry mixture. The dewatering action occurs both by overflow

at the top as heavy ash settles and through dewatering screens located inside the tank. The dewatered ash is unloaded through a cylinder operated gate into trucks waiting below. The new dewatering bin, however, could not retain some of the fine ash produced by our wood burning boilers. Therefore, we decided it would be necessary to send the overflow water to our existing water clarifier (via gravity feed) before it was discharged to the surrounding environment. The total price for this equipment was $150,000 excluding installation.

After finishing my investigations of the wet and dry ash handling systems, I stated the results in a letter to Jerry Brown, Ed Thompson and Jim Riggs, the superintendent of the power department. They reviewed the alternatives and made the decision on what to recommend to management, thus ending my first engineering project.

Several months later I found out that the new scrubber being installed on the boilers would be on a system separate from the ash handling system, thereby eliminating future safety hazards. Based on this and other considerations, management decided to stay with the existing steam ejector condenser rather than installing any new equipment.

APPENDIX

REQUEST FOR ENGINEERING

Category

TO: Mill Engineering Department

DATE: August 5, 1974

ENGR. PROJECT NO. 14-1012

JOB OR CENTER NO. 721

Replace Steam Ejector - Condenser

DESIRED COMPLETION DATE

Ash Handling System
(PROJECT TITLE)

ORIGINATING DEPT. Power

(x) ESTIMATE ( ) LAYOUT & DETAIL ( ) PREPARE JOB ORDER (x) Study

DESCRIPTION OF WORK: Investigate cost, feasibility, and return of replacing steam ejector-condenser on the United Conveyor ash handling system with a motor driven vacuum pump

J. C. Riggs
NAME OF PERSON ORGINALLY REQUESTING THE WORK TO BE DONE.

(FOR ENGINEERING OFFICE USE)

SHOULD AN ENGINEERING PRONECT FILE BE SET UP FOR THIS PROJECT? YES ______ NO ______

ASSIGNED TO: Jerry Brown

DATE COMPLETED W/E

REMARKS:

cc: Project Book

File

UNION CAMP

TO Mr. J. M. Helmey AT Savannah SUBJECT ENGINEERING PROJECT ASSIGNMENT

FROM J. Brown AT Savannah DATE January 13, 1976

cc: Messrs. H.B. Stuart, Jr.
J. C. Meredith

RE: "Replace Steam Ejector - Condenser Ash Handling System"

Description of Work

Investigate cost, feasibility, and return of replacing steam ejector condenser on the United Conveyor Ash Handling System with a motor driven vacuum pump.

Discussion

Steam has become an extremely expensive way to produce a vacuum. For caluculating the cost comparison, you will need to calculate the cost of operating and maintaining the present system and the cost of buying, installing, operating and maintaining a motor driven vacuum pump system at the present plant site.

The calculations or measurements that you will need are listed below. This list is to be used as a guide only. If more calculations come up during your work, I would expect you to do what is necessary to come up with an accurate cost and feasibility study.

Calculations and Measurements:

1. Measure steam flow rates to existing system.

2. Measure steam pressure to existing system.

3. Measure vacuum generated by present system with new and old parts.

4. Calculate energy used for present system.

5. Calculate size of vacuum pump needed to replace present system.

6. Calculate size of motor to drive the vacuum pump.

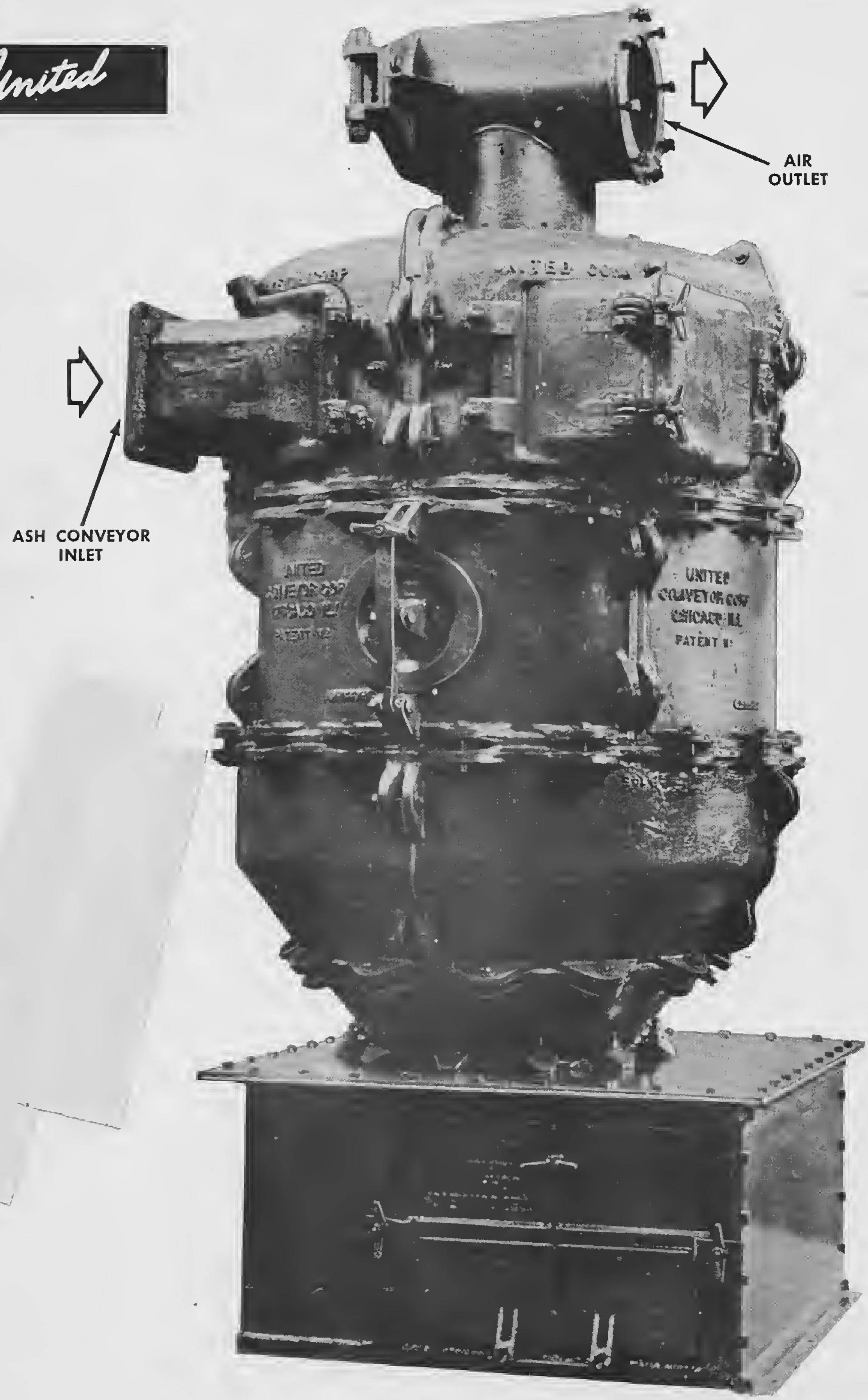
7. Calculate structural supports for vacuum pump, drive and foundation, if you choose to locate new system at fifty (50') foot level on side of building as the present system is.

8. Calculate projected energy usage rates for new system.

9. Calculate projected maintenance cost.

Jerry Brown

JLE/az


United
AIR
OUTLET
ASH CONVEYOR
INLET

Evaluation of steam & motor costs

Assumptions:

1) \$12 per bbl oil
2) Boiler efficiency = .85 $\frac{BTU\,(STM)}{BTU\,(OIL)}$; $6.27 \times 10^6 \frac{BTU}{bbl\ oil}$
3) steam ejector operates 24 hours per day, 360 days/year
4) steam from the power boiler goes through a turbine which gets work out of it: 1127 $\frac{BTU}{lb\,(1200\ lb\ steam)}$

I. Steam Ejector (cost of steam)

$$3100 \frac{lb\ 150\#\ stm}{hr} \times .628 \frac{lb\,(1200\#\ stm)}{lb\,(150\#\ stm)} \times 1127 \frac{BTU}{lb\,(1200\#\ stm)}$$

$$\div .85 \frac{BTU\,(STM)}{BTU\,(OIL)} \div 6.27 \times 10^6 \frac{BTU}{bbl\ oil} \times 12 \frac{\$}{bbl\ oil}$$

$$\times 24 \frac{hr}{day} \times 360 \frac{day}{year} \times \frac{150}{180} \frac{sec}{sec}$$

= **\$36,000 per year**

II. Vacuum Pump (cost of motor)

Assume: efficiency = .85 155 hp motor
.028 \$/kwh

$$.746 \frac{Kw}{HP} \times .028\ \$/kwh \times .85 \times 24 \frac{hr}{day} \times 360 \frac{day}{year}$$

$= 153 \frac{\$}{hp\ year}$

$155\ hp \times 153 \frac{\$}{hp\ year}$ = **\$23,700 per year**

III. Savings on energy

36,000 − 23,700 = **\$12,300 per year**

UNION CAMP CORP.				SAVANNAH, GEORGIA		DWG. NO. ES
TITLE Flow Diagram - Ash From No. 11 & 12 Power Boilers						C H G
DRAWN BY	ENGINEER	CHECKED	APPROVED	SCALE	DATE	LTR. / REVISION
Helmey				None	1-29-76